SHORT TERM SCIENTIFIC MISSION (STSM)
SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator

Action number: CA15211
STSM title: Investigating the utilization possibilities of Schumann resonance data measured at Mitzpe Ramon (Israel)
STSM start and end date: 24/11/2019 to 01/12/2019
Grantee name: Tamás Bozóki

PURPOSE OF THE STSM:

The main purpose of the completed STSM was to facilitate common scientific objectives between two groups dealing with Schumann Resonances (SRs) at Tel Aviv University (Israel) and at Geodetic and Geophysical Institute (Hungary). Wise observatory near Mitzpe Ramon (MR, 30° 35′ N 34° 45′ E) operated by Tel Aviv University has been measuring SRs continuously for almost two decades and provides highly valuable SR data for various research purposes. Mitzpe Ramon is among the very few observation sites on the globe where the electric and the magnetic field components of SRs are registered parallel. The STSM enabled to exchange the indispensable 'background' knowledge for data sharing and provided the possibility to discuss the current scientific interests of the two groups. The important characteristics, like data availability and storage, the possible sources of local noise contamination, the suggested filtering and data processing methods etc. of MR SR measurements had been clarified and a python-based algorithm had been developed to process the raw measurements.

The applicability of the obtained algorithm had been demonstrated by investigating a monthly period of MR SR data around a series of larger, shallow depth earthquakes (EQs) under the Sea of Galilee in Israel. There are more and more scientific results in the literature claiming that SR could be a sensitive indicator of the lithosphere-atmosphere-ionosphere coupling mechanisms connected to earthquakes (e.g. Christofilakis et al., 2019). The result may add to the work carried out by Attila Buzás during his STSM visit in Israel who investigated the same period based on several other geophysical measurements (potential gradient, integrated water vapour, total electron content, water conductivity, water level).

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

24/11/2019: arrival to Israel, short discussion with Colin Price, check-in at the hotel

25/11/2019: meeting with Judi Lax, discussion about her topic: atmospheric electricity and renewable energy. Attending the Geophysics Seminar at Tel Aviv University. Developing a python algorithm for reading in the older data format of MR.

26/11/2019: meeting with Tair Plotnik, discussion about the most important characteristics of MR measurements and developing a python algorithm for reading in the new, LabView based data format of MR. Processing and visualizing 19 days of MR SR data from 2019-10-07 to 2019-10-25. Identifying typical forms of noise contamination.

27/11/2019: meeting with Colin Price, discussion about the following topics: all about Mitzpe Ramon SR measurements (data availability, data processing, noise sources etc), the current state of the SR inversion project carried out by the Hungarian group, global lightning activity on ENSO timescale as indicated by SR measurements, the future of investigating the possible effect of SRs on biological systems. Developing a noise filtering algorithm in python based on Guha et al. (2017) and applying it on MR SR measurements.

28/11/2019: meeting with Dekel Shahar, discussion about his topic: the possible indications for flash floods in Israel based on ENTL lightning detection. Meeting Colin Price, discussion about the planned scientific program of the upcoming Cost ElectroNet SR workshop in Santander, plans for investigating SR measurements near large magnitude, european EQs. Meeting with Tair Plotnik and discussing the plans for future collaboration. Meeting with Tamir Tzadok, discussion about his topic: the origin of near Earth gamma radiation enhancements.

01/12/2019: Check-out from the hotel, flying back to Hungary.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

The STSM enabled to create a comprehensive metadata file about MR SR measurements which yields a very important starting point for future scientific utilization of the data (Table 1).

Abbreviation:	MRN, MR	
Country:	Israel	
Geo lat:	30.61	
Geo lon:	34.8	
L:	1.3	
Data availability:	1998 summer	2015 may
Sampling freq:	250	125
Measured components:	HEW, HNS, Ez	HEW, HNS, Ez
Length of data unit:	2 min	30 min
Data format:	.txt	.tdms
Calibration:	magnetic calibrated, electric not	
Noise sources:	Telescope rotation, cars, wind/dust/wetness /fog for electric	
Contact:	Colin Price (cprice@flash.tau.ac.il) Tair Plotnik (tairplotnik@mail.tau.ac.il)	

Table 1 Metadata file for MR SR measurements

A new processing algorithm had been implemented in python which as a first step provides the dynamic spectrograms of the measurements (Fig. 1) which is a very convenient way for identifying periods with noise contamination. Altogether 19 days of MR SR data had been processed from 2019-10-07 to 2019-10-25 and some typical form of noise appearance had been identified. The processing algorithm had been implemented for both: old and new data storing format of MR SR measurements (see Table 1).

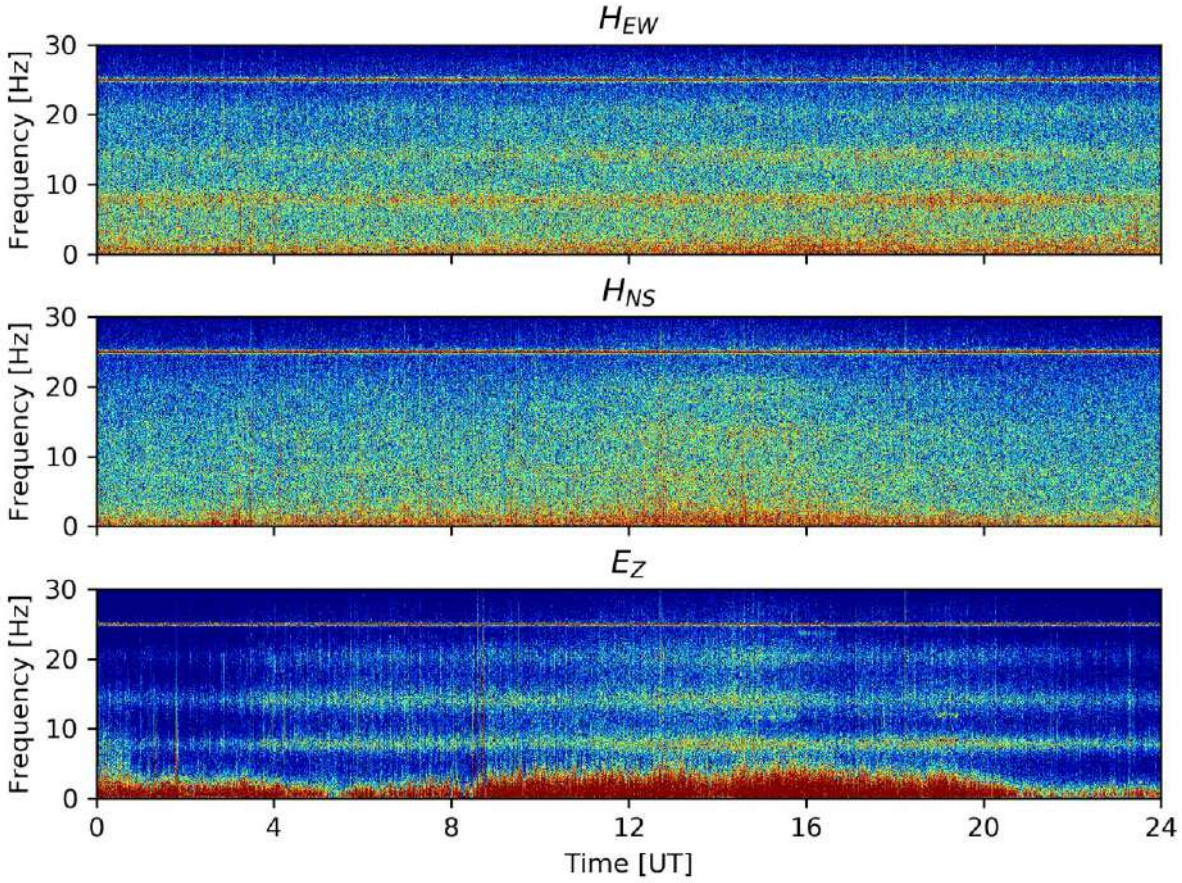

Fig. 1 Dynamic spectrograms of the HEW, HNS and Ez components for 20.10.2019. A day with very high quality data in all the three measured field components.

As a next step a noise filtering algorithm based on Guha et al. (2017) had been implemented in python and specified for MR SR measurements. The method divides a 12 min long time interval into ~10s long segment, calculates their total spectral energy content and dismisses the segments with extraordinary large total spectral energy content. This method enables to filter short-time, large amplitude anomalies from the measurement with both natural (Q-bursts) and artificial origin. The selection of segment size and the threshold for segment dismission had been specified for MR SR data. A spectrogram before and after noise filtering is shown by Fig 2. This filtered dataset is ready for further processing, i.e. extracting SR spectral parameters (amplitude frequency). All the developed algorithms had been shared with the host institute.

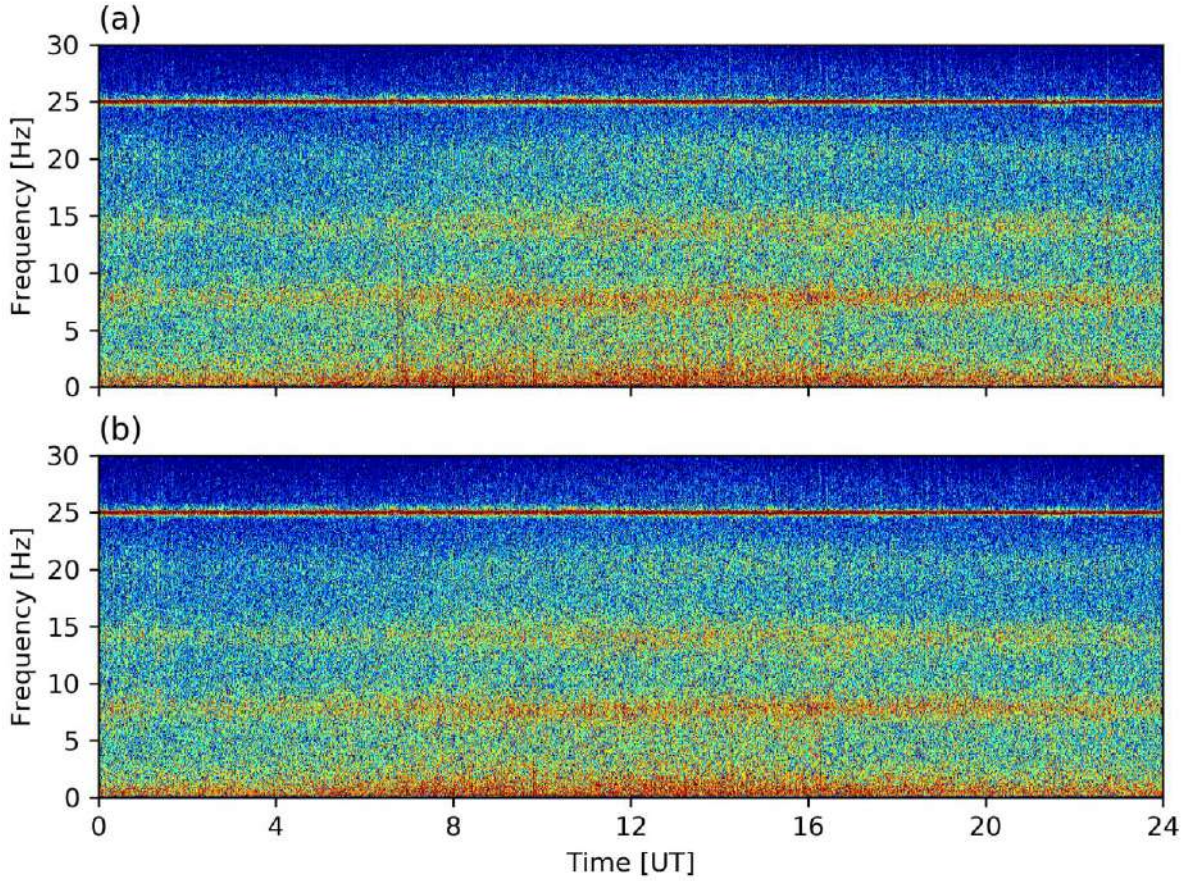

Fig. 2 Dynamic spectrogram before (a) and after (b) noise filtering for 10.10.2019.

The applicability of the new algorithm had been demonstrated by processing a more than one month long period from June and July 2018 around a series of larger, shallow EQs near the Sea of Galilee in Israel. The largest magnitude EQ happened on 04.07.2018 at 19:45 UTC. This specific period had been processed by Attila Buzás as well in respect of several other geophysical measurements (potential gradient, integrated water vapour, total electron content, water conductivity, water level). Although MR is more away from the EQ's epicenter (> 200 km) than the measuring sites elaborated by Attila Buzás, few hundred kilometers can be regarded as 'local' in respect of a change in the propagation conditions for SRs (Nickolaenko and Hayakawa, 2014). On the other hand it is to be noted that the SR anomaly identified by Christofilakis et al. (2019) appeared much closer to the EQ's epicenter than in this case. Although in the past there were some large magnitude EQs near MR as well (e.g. on 11.02.2004, 27.06.2015) the archived SR data could not be retrieved until now due to technical reasons.

In the selected time period MR SR data is available from 13. June to 20. June and from 30. June to 31. July. The data had been processed with the algorithm described above and SR spectral parameters were calculated by applying the spectral deconvolution method (Sátori et al., 1996). The results are shown by Fig. 3, which contains the frequency and the amplitude variation of the first SR mode in the vertical electric and the HEW horizontal magnetic components.

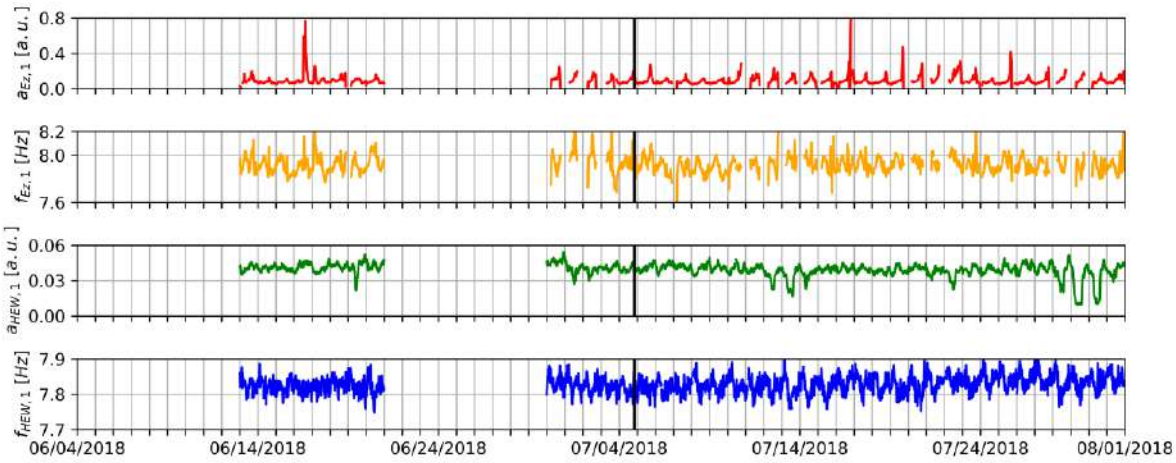

Fig 3 SR spectral parameters (amplitude and frequency) for the first SR mode in the electric and the HEW magnetic components. The HNS magnetic measurement was not working well in the investigated time period. The time of the main EQ is marked with horizontal black lines.

All the presented SR spectral parameters show pronounced daily variations which makes the identification of anomalies difficult. It is known that the electric component is highly influenced by local weather conditions (see Table 1) which is probably the reason for the big anomalous peaks in the obtained amplitudes. This should be verified by comparing the result with local meteorological measurements in the future. It is interesting to note that the frequency of the electric component shows much higher variability before the EQ than in other time periods. The amplitude of the HEW magnetic component shows anomalous big variability ~10 days and ~30 days after the EQ. It is unlikely that these anomalies are connected to the EQ. The frequency of the HEW magnetic component does not show any eye-catching anomalous behaviour. Unfortunately, the HNS magnetic measurement was not working well in the investigated time period.

References

Christofilakis, V., Tatsis, G., Votis, C., Contopoulos, I., Repapis, C., & Tritakis, V. (2019): Significant ELF perturbations in the Schumann Resonance band before and during a shallow mid-magnitude seismic activity in the Greek area (Kalpaki). Journal of Atmospheric and Solar-Terrestrial Physics, 182, 138-146. https://doi.org/10.1016/j.jastp.2018.11.009

Guha, A., Williams, E., Boldi, R., Sátori, G., Nagy, T., Bór, J., Montanyá, J., & Ortega, P. (2017): Aliasing of the Schumann resonance background signal by sprite-associated Q-bursts. Journal of Atmospheric and Solar-Terrestrial Physics, 165–166, https://doi.org/10.1016/j.jastp.2017.11.003

Nickolaenko, A. P., & Hayakawa, M. (2014): Schumann Resonance for Tyros. Japan: Springer. https://doi.org/10.1007/978‐4‐431‐54358‐9

Sátori, G., Szendroi, J., & Vero, J. (1996). Monitoring Schumann resonances–I. Methodology. Journal of Atmospheric and Terrestrial Physics, 58(13), 1475‐1481. https://doi.org/10.1016/0021‐9169(95)00145‐X

FUTURE COLLABORATIONS (if applicable)

The STSM at Tel Aviv University enabled a really fruitful exchange of scientific knowledge between C. Price, T. Plotnik, J. Lax, T. Tzadok, D. Shahar and the graintee. Many fields of common interested had been identified and plans for future collaborations had been discussed, which involves the following fields: possible earthquake related SR-anomalies, global lightning activity on ENSO timescale, SR-inversion, the possible effect of SRs on biological systems. Probably the most important achievement of the STSM was that it facilitated the utilization of Mitzpe Ramon SR measurements in further SR-related studies.

It is planned for the near future to apply the obtained algorithm for processing Mitzpe Ramon SR data around two large magnitude earthquakes near the observation site at 11.02.2004 and at 27.06.2015. The results are planned to be presented at the 2020 Cost ElectroNet meeting in Beograd.